Communication Theory (5ETB0)
Module 1.1

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For more info

http://www.sps.tue.nl/ http://www.tue.nl/ictlab/

Before and After 5ETB0

Level (Before)

- Prerequisites: Mathematics II (5EMA0) and Intro telecommunications (5ETA0)
- Expected knowledge in signals and systems: Fourier theory, LTI systems, probabilities, etc.
- 8 Weeks, 5 ECTS. 1 ECTS $\approx$ 30 hours $\rightarrow$ 140 hours course, $\approx$ 18 hours/week

What After 5ETB0?

- 5XSE0 Information Theory (Q3, BSc) (The course is on-hold for the year 2024-2025)
- 5LSF0 Applications of information theory (Q4, MSc)
- 5LSK0 Digital wireless communication exploration lab (Q4, MSc)
- 5LPA0 Wireless Communications (Q2, MSc)
- 5LTB0 Fibre optic communication systems and networks (Q4, MSc)
- 5STA0 Optical fibre communication technology (Q3, MSc)

Coherent Package

Machine Learning and Information Processing for Communications

ICT Lab offers a coherent package covering digital information from telecommunications, information theory, and machine learning perspectives.

Information and communication technologies ID 116557498 ©Funtap P Dreamstime.com

Course Code	Code Name	Schedule
5XSL0	Fundamentals of Machine Learning	Q4 (timeslot D), year 2
5XSE0	Information Theory*	Q3 (timeslot A), year 3
5XTA0	Telecommunication systems	Q4 (timeslot B), year 3

* The course is on hold for the year 2024-2025

https://www.sps.tue.nl/ictlab/education/

Learning Outcomes

After completion of this course, the student should be able to:

- Summarize the advantages and disadvantages of digital communication systems.
- Explain the properties of white Gaussian noise and the differences between wideband, baseband, and passband channels.
- Determine the optimal decision rules and resulting error-probabilities for scalar and vector channels with discrete and real-valued outputs.
- Use the Q-function for evaluating error probabilities.
- Explain the differences between MAP and ML receivers in terms of optimality, complexity and performance.
- Compute the energy of signals and test orthogonality.
- Determine the vector representation of signals by constructing a set of building block waveforms.
- Use Parseval's relationship to solve equivalent time-frequency domain problems.
- Design and implement correlation, matched filter, and direct receivers for the AWGN channel.
- Explain the connection between a matched filter and the resulting signal-to-noise ratio.
- Describe the concept of signal structure and the effects of translation and rotation on the error probability.
- Recognize orthogonal signals, construct optimum Rxs for such signals, and explain the behavior of its error probability when the number of signals increases.
- Evaluate and compare the performance of communication systems in terms of signal-energy, bandwidth (dimensionality), and signal-to-noise ratio.
- Compare the performance of bit-by-bit and block-orthogonal signaling.
- Estimate the number of orthogonal waveforms N (dimensions) that can be fitted into a given bandwidth W.
- Explain the concept of channel capacity and its relation to transmission rate, block length, and error probability.
- Determine and estimate the capacities of band-limited, wide-band, and band-pass-channels.
- Explain the general principles behind the proof of Shannon's channel capacity theorem.
- Explain the importance of the Nyquist criterion and recognize pulses that satisfy this criterion (both in time and frequency domain).
- Describe the role that sinc pulses play in terms of transmission with minimum bandwidth.
- Use cosine and sine functions to transmit information in a passband channel.
- Compute the capacity of the passband channel and compare it to the equivalent baseband channel.
- Compute error probability of QAM constellations using Q-functions.
- Construct and analyze optimal receivers incoherent transmission.
- Explain and implement different blocks that form a standard digital communication system.

Course Elements (1/2)

Parts

- **Lectures (Alex)**: Divided in 12 modules plus 1 invited lecture. Live lectures based on pre-recorded videos.
- **Instructions (TAs)**: 2 per week, each on single module discussed in lecture. Mix of self-study problem solving and problem solutions by TAs. Preparation for **same-day** quiz.
- **Quizzes (TAs)**: 2 per week (except: first week (only on Nov. 13), during Q&A sessions, and the invited lecture)
  2 questions: first, about the lecture/video lecture and second, taken from the exercise bundle. Not mandatory but part of the final grade
- **Q&A Sessions (TAs)**: To discuss modules/quiz/assignment content. If there are no questions, the session will be cancelled
- **Assignments**: 3 assignments, each with a mathematical problems part, and a second part with one MATLAB problem. Part of the final grade
- **Study Guide**: All you need to know about the course
- **Course Reader**: 12 Chapters
- **Written Exam**: Jan. 22 2024 13h30m Mandatory (re-sit on April 12 13h30m)

Course Elements (2/2)

Exercise Bundle

- Contains exercises grouped per chapter
- Answers **and solutions** to all exercises are provided
- Student-driven. Exercises may be explained by TAs if multiple students have the same question.

A Typical Day

- Lecture
- Instruction
- Quiz + Q&A Quiz
- Instruction/Lecture

Course Planning

Course Planning						
Date	**Module**	**Instruction**	**Quiz**	**Lecture**	**Assignment**	
					Release	Submission
11 Nov.	M1	-	No	Live		
13 Nov.	M2	M2	Yes (M2)	Half-half		
18 Nov.	M3	M3	Yes (M3)	Half-half	A1	
20 Nov.	M4	M4	Yes (M4)	Half-half		
25 Nov.	M5	M5	Yes (M5)	Half-half		
27 Nov.	M6	M6	Yes (M6)	Half-half		
2 Dec.	Q&A Session	M1-6 + A1	No	No	A2	
3 Dec.	-	-				A1
4 Dec.	M7	M7	Yes (M7)	Half-half		
9 Dec.	M8	M8	Yes (M8)	Half-half		
11 Dec.	M9	M9	Yes (M9)	Half-half		
16 Dec.	M10	M10	Yes (M10)	Half-half		
18 Dec.	Q&A Session	M1-9 + A2	No	No	A3	
19 Dec.	-	-				A2
6 Jan.	M11	M11	Yes (M11)	Half-half		
8 Jan.	M12	M12	Yes (M12)	Half-half		
13 Jan.	Invited Lecture	-	No	Live		
15 Jan.	Q&A Session*	M1-12 + A3	No	No		
16 Jan.	-	-				A3
22 Jan.	**Final Examination**					

* The Q&A Session on the 15 Jan. will only be with the TAs.

Extra Info

Do you need a quick answer?

Take a look at www.wikipedia.org, www.google.com, or ask ChatGPT

Do you need a slow (but better) answer?

Take a look at the reader, additional reading material, or ask a question!

How to Contact Us?

- During Q&A Sessions and Instructions
- Request a meeting via email with any of the course staff
- Visit us in Floor 7 of Flux building

Details

Lectures

- The video lectures cover essentials only. Watch the pre-recorded lectures before coming to the lecture!
- All details in the course reader
- A combination of slides, examples, and MATLAB demos will be used

Instructions

- Solutions can be found in the Exercise Bundle
- Instructions consist of a mix of
  - Guided self-study
  - Solution of selected problems
  - Q&A
- Try to read and solve the problems before the exercise session
- Complete (at home) potentially unfinished self-study exercises
- The level of the problems is often, but not always, similar to the level of the exam's problems

Quizzes and Assignments

Details

- **Quizzes** will consist of simple questions to evaluate your knowledge on the course
- Questions in **quizzes** will be mostly theoretical, but small calculations can be present
- **Quizzes** will be paper-based
- The three lowest score quizzes will not be considered in the quiz grade calculation
- **Quizzes** will be placed after the instructions and will be 15 minute long
- **Assignments** are more elaborated and can consist of programming tasks or more difficult questions involving calculations
- You will have more time (days) to solve **assignments**
- **Assignments** will require MATLAB

Written Exam

Details

- **Understanding** communication theory will be rewarded
- Emphasis is not on memorizing facts or solving standard problems
- Aim for understanding **during the course**. The earlier the preparation starts, the better.
- The **solution** is more important than the **answer**:
  - A good solution with a minor error usually gives close to full points, even if the answer is incorrect
  - An answer without a clear motivation usually gives 0 points, even if it is correct
- **Instructions** and **Q&A Sessions** will help you improve your understanding. Use them!
- Equations (max one-page) will be attached to the exam. File in Canvas already.

Grading and Rules

Grading

- Individual grades
- Final Grade = Exam 70% + Quizzes 10% + Assignments 20%
- Exam grade must be at least 5.0

Remember...

- **Questions** are always very **welcome**
- **Late arrivals** are **not welcome**
- **Interactions** are encouraged during instructions and Q&A sessions

Cheating

- Group discussions are encouraged
- Plagiarism software for code
- Plagiarism will be reported

Summary Module 1.1

Take Home Messages

- Course Overview
- Online Course:
  - Pre-recorded Lectures
  - Q&A Sessions
  - Instructions
- Final Grade:
  - Exam
  - Quizzes
  - Assignments

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